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all, there must be an unstinted and undying, a genuine and universal, pride in the greatness and the glory of an undivided republic.

HENRY LITCHFIELD WEST.

BIRDS AND THE ATMOSPHERE.

I HAVE read with much interest an extract from an article in the NORTH AMERICAN REVIEW, by Mr. Hiram S. Maxim, on "Birds and the Flying Machine." In 1891 I suggested that the soaring of birds might sometimes be done by means of upward currents, caused by the heating of the lower strata of the atmosphere by the sun. My explanation is derived from the theory of equilibrium of the atmosphere, given by the late Mr. William Ferrel in his "*Popular Treatise on the Winds.*" It occurred to me that a similar state of unstable equilibrium of the atmosphere to that which causes destructive tornadoes might, when the degree of instability is much less, give rise to ascending currents, which birds could use for flight with motionless wings. In *Nature*, October 1st, 1891, I wrote: "These birds," sea gulls and harriers, "begin to soar at a height of about 200 feet, and rise in slanting spirals to 2,000 feet and under. The gulls are much the most numerous, and flocks of them may be seen soaring nearly every fine day in summer. Sometimes a number assemble, and after going round in circles for a short time, without rising, or rising very little, they come down, the condition of the air being apparently unfavorable for soaring. Whenever I have seen a flock finish an ascent, they all reached the same height, which is consistent with the supposition that they go as high as they can. They never remained at the limit of their ascent, even for a short time, but separated, sailing away downward to great distances.

"The explanation of soaring at great heights, which presents fewest difficulties seems to me to be—that it is done by means of upward currents. This has been suggested by several observers, its main difficulty being the uncertainty that there are such currents of sufficient strength. I shall try to show that upward currents may be caused in two ways.

"Everyone who has watched the working of a windmill, must have seen that the force of the wind varies frequently, and sometimes rather suddenly. It is evident that there must be an ascent of air in front of a current moving faster than the average speed, and a descent of air behind it. As an example of this, when a cold southwest wind was blowing, with showers of rain at intervals, accompanied, as often happens, by increased force of the wind, I once saw a flock of gulls soaring in front of one of these squalls. There can, I think, be little doubt that there was an ascending current, of which the gulls took advantage.

"Mr. W. Ferrel has shown ("*Popular Treatise on the Winds*") that if the rate of fall of temperature with increase of height, be greater than the rate of dynamical cooling of an ascending current, the atmosphere is in an unstable state—that is, if by any cause a mass of air be started in an upward direction in such an atmosphere, the density of the ascending air is less than that of the surrounding still air, so that the former would be driven upwards and an ascending current established which would tend to rush up to the top of the atmosphere, if the instability consequent on the vertical decrease of temperature should extend all the way up; but if the instability did not extend to the top, then, at its limit, the impelling force would cease, and friction would soon bring the ascending current to rest. Conversely in an unstable atmosphere, if a mass of air be started downward, the density of the descending air is greater than that of the surrounding still air, and the descent tends to continue down to the ground. Mr. Ferrel says (page 440): 'The unstable state in unsaturated air occurs mostly on very dry and sandy soils with little heat conductivity, when the weather is very warm and the heat rays of the sun are unobstructed by any clouds above. The heat thus accumulates in the surface strata of the soil and the lower strata of the atmosphere, and thus is brought about the unstable state, at least up to a low altitude even in clear dry weather.' And in speaking of what may be called a multiple tornado (page 412): 'As the tornado originates in air in the unstable state, it often happens that there is about an equal tendency in the air of the lower stratum, to burst up through those above at several places in the same vicinity at the same time.' This tendency of the lower strata to burst up in separate spots may exist where the instability is much less than that required to cause a tornado, as in the case of a plain strongly heated by the sun and in the absence of any gyratory motion round the center of an ascending current, there would be no whirlwind, only a quiet ascent of air, in a slanting direction if there were any wind. Such ascending currents may be of small area, not much larger than the circles described by birds when soaring. It seems possible that the object of describing circles may be to keep within the ascending current.

"It is obvious that upward currents over a plain caused either by variations in the velocity of the wind, or by the unstable state of the atmosphere, must be almost insensible near the ground, and could not attain their full strength under a considerable height. This accounts for the fact that over plains birds do not begin to soar at less than about 200 feet. If soaring were possible in a uniform horizontal current, they would save themselves the muscular effort of rising 200 feet and over by the active use of the wings, and would begin to soar immediately on leaving the ground."

As under a hot sun the air is seldom without horizontal motion, masses of air may be started in an upward direction by any obstacle, such as a rising ground, a bush, etc., and an ascending current so caused will draw in air all round, and tend to increase in area. Also when an upward current is started, it necessarily follows that a downward current must start somewhere else, probably on the outside of the former current. Mr. Ferrel has shown that in an unstable atmosphere, descending air is impelled downward by a force equal to that which impels ascending air upward. When the downward current approaches the ground, it must, by Mr. Ferrel's theory, be colder than the surrounding air, and the stability of the column of air at that point is restored, so that the ascending and descending currents cease.

In hilly country the motion of the air must be modified by the diversion upwards and downwards of the horizontal current, and upward currents of larger area and greater force than over plains may result.

Mr. Hiram S. Maxim says: "With the albatross and sea-gull, it will be found that they always occupy the same position as relates the ship, . . . but whenever they find themselves in front of the ship, or on one side, where there is no ascending column of air, they have to work their passage very much as other birds do." This is true as to the gulls on the New Zealand coast, but the albatross Mr. Maxim is speaking of must be a different species from the giant of the Southern Ocean. For a description of the flight of the Southern albatross, I may refer to a letter in *Nature* of May 2, 1889, by me, and to one by Lord Rayleigh in the following number.

A. C. BAINES.